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EMBEDDED TRAINING: UTILIZATION OF TACTICAL COMPUTERS TO TRAIN TACTICAL COMPUTER OPERATORS

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MANPOWER AND EDUCATIONAL SYSTEMS TECHNICAL AREA

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The concept of Embedded Training (ET) involves programming and using the extra capacity of Army tactical data processing systems to train tactical system users in how to use the system. The Army Research Institute (ARI) has developed embedded training that does not require previous knowledge by the trainee and that progresses from basic individual skills to complex team interaction. It can also be used in a stand-alone mode to teach non-system skills, as the initial test demonstrated.

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The initial test of the ET concept successfully used the PLANIT author language on the Army's Developmental Tactical Operations System (DEVTOS) to teach basic infantry skills and GED math. A subsequent test examined the ET concept using TACFIRE (Tactical Fire Direction System) as the target computer system. To accomplish this, PLANIT-based CAI software was translated into the language of the TACFIRE computer and installed.

The latter, field evaluation of the primary role for ET demonstrated that ET is at least as effective as traditional methods of training. A preliminary cost and training effectiveness analysis indicates a saving of over 6 million dollars if the ET procedure is used in place of the system proposed in the original TACFIRE Individual-Collective Training Plan (ICTP). Current indications are that ET will be adopted in place of the original ICTP.

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Embedded Training

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FOREWORD

The Manpower and Educational Technology Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) conducts on-going research on computer-based educational systems (Army Project 2Q162722A791, FY 80) and training simulation (Army Project 2Q163744A795, FY 80). The forerunner of the current research is described in this report.

An effort in the Command Systems Work Unit of ARI had been designed to optimize commanders' use of Army tactical data systems for command and staff information processing and decisionmaking, by developing software packages that would use the actual system as the instructional vehicle for training users and maintaining their proficiency. The research reported here stemmed from that effort.

This research used tactical data systems in a computer-assisted instruction (CAI) mode to support MOS 11B40 infantry training at the combat unit level. The particular problem area was selected when the training of 11B40 soldiers came up as a critical item in the report of the Board for Dynamic Training in 1971 and in the Continental Army Command (CONARC) Task Group Report on Computer-Assisted Instruction in 1972.

ARI's programs are conducted as in-house research augmented by contracts with organizations having unique capabilities in the area. Much of this experiment was conducted by personnel of the System Development Corporation (SDC) under contract DAHC19-73-C-0029. The entire effort responded to requirements of Project 2Q062106A721, Human Performance in Military Systems, FY 1973 Work Program, and to special requirements levied by what were then Assistant Chief of Staff for Force Development and the Director of Army Research, Office of the Chief of Research and Development. Current programs are responsive to requirements of Army Training and Doctrine Command (TRADOC), the successor to CONARC.

Dr. John E. Germas received the Army R&D Achievement Award, posthumously, for devising and developing Embedded Training System Technology and successfully applying it for effective operation of the Army's computerized tactical data systems.

Joseph Zeidner

JOSEPH ZEIDNER
Technical Director

EMBEDDED TRAINING: UTILIZATION OF TACTICAL COMPUTERS TO TRAIN TACTICAL COMPUTER OPERATORS

BRIEF

Requirement:

To determine if Army tactical data systems can be used to support unit and individual training requirements when they are not being used for tactical operations.

Procedure:

The approach is to develop methods, techniques and tools for embedding training subsystem packages within the operating system and then to use the system itself to (a) teach the user how to use the system; (b) to maintain these skills once learned (proficiency maintenance); (c) to provide on-line situation problems which will permit the training and exercising of complex team interactions; and (d) if desired, to permit the system to teach crucial, non-system tied military skills as well. The overall effort required a multi-disciplinary approach capitalizing on state-of-the-art developments in computer science, computer-assisted instruction and instructional technology.

Findings:

The efficacy of a concept for machine-independent, transportable software for authoring and training, namely, the Programming Language for Interactive Teaching (PLANIT) developed by the National Science Foundation, was tested and validated in these applications reported in this report. The Embedded Training (ET) concept was found to be viable for teaching non-system tied military skills during MASSTER Test 122 at Ft Hood, Texas, as well as for teaching tactical data system skills using the TACFIRE system at Ft Sill, Oklahoma. The technique was found to be an effective vehicle for training, as well as being substantially cost effective when compared to alternative approaches for meeting the same requirements.

Utilization of Findings:

The ET approach to training Tactical Fire Direction System (TACFIRE) operations will be adopted over alternative Individual-Collective Training Plans proposed for TACFIRE. The estimated savings in the selection of ET over other alternatives is approximately 6 million dollars. The technique indicates that it is completely feasible to extend the concept to encompass totally hands-on skill qualification testing (SQT) of TACFIRE operators and research will commence to achieve that end.

EMBEDDED TRAINING: UTILIZATION OF TACTICAL COMPUTERS TO TRAIN TACTICAL COMPUTER OPERATORS

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INTRODUCTION

The U.S. Army has been developing several highly complex tactical data processing systems and will soon possess a considerable data processing capability in the field. The Army recognizes that full exploitation of the capability of these data processing systems requires knowledgeable and dedicated system users. As the tactical data systems become part of the Army's inventory, there are immediate and sustained requirements for skilled personnel to operate these systems.

In the past, the required personnel would have been sent from the unit to a school for the appropriate training. In addition to the Army's shift in emphasis away from school training, such an approach has several problems: (a) the high cost of transporting the trainees away from their units and maintaining the trainees at the school, (b) degradation of unit efficiency as a result of removing key personnel from a unit for training at a school when personnel levels have been cut back severely, and (c) the transfer of training from the school to the unit.

The problems with school-based training have their counterparts in training at the unit level in the field. Training in the field may be of a lower caliber than school-based training. Field training often may not have well-qualified instructors or validated and consistent instructional programs.

Embedded training (ET), a training concept for teaching tactical data system operators, addresses the aforementioned problems and offers some additional substantial benefits. Embedded training, in the context of training tactical data system users, means using the tactical computer to train the user to use the system. The concept of embedded training or operational context training is not new (Hoehn, Woolman, & Glaser, 1969). Trainers have long realized the advantages of conducting training in the operational setting. Several unique characteristics distinguish the concept of ET developed by the Army Research Institute (ARI) from earlier similar concepts (Powell & Streich, 1964; Morrill, 1967).

First, the tactical system ET provides the naive student with immediate hands-on experience with the equipment. The student is first taught the basic skills required to interact with the tactical computer. Instruction progresses to the point where the student is taught the most complex man/computer interactions. In view of the complexity of the tactical computer equipment and of the message formats used to input information to the system, early successful hands-on experience can be pivotal in terms of producing the attitudes which enable a naive trainee to become proficient at operating such a system. In this sense the tactical-computer-based ET developed by ARI provides the opportunity to begin students' training on the equipment on which they will eventually perform their jobs. Many previous implementations of the notion of ET required the trainee to possess some particular knowledge or experience before ET could be employed.

For example, the Interactive Training System of the IBM Corporation uses the concept of ET wherein the computer terminal that is replacing manual data entry methods is used to teach the procedures for on-line data entry through the terminal ("Teaching New Skills," 1975). The personnel being trained are currently performing the manual data entry, and thus they are knowledgeable and experienced regarding the type of data to be entered. The ET employed for training the users of tactical computers does not require that the trainee know anything about the tactical system.

A second distinguishing characteristic is that ET provides for coherent and systematic progression through multiple levels of training objectives. This feature makes it possible for any student, regardless of entry level skills and knowledge, to enter the embedded training system at a level appropriate to that student's training needs. The training objectives related to tactical data systems have been categorized into four levels (Figure 1). The goal of the ET concept is to provide a single effective method to deal with training problems at any level.

Training at the first level provides the user with basic components upon which all remaining training depends. The training objectives at t base of the pyramid are related to acquisition of fundamental skills, s as operator procedures, mnemonics, and message formatting. Embedded tr ing permits naive students to successfully use the system to help them a quire basic operating procedures while becoming gradually more familiar and comfortable with the imposing tactical computer.

Training at the second level integrates the basic components into appropriate functional areas. Entry into level two training provides the user with experience in using the skills learned at level one in consort. This training is based on task clusters, which group appropriate job elements to produce operator skills and knowledge that permit the student to function in a given job.

Training at level three is directed at the staff elements of the tactical data systems. The extant tactical data systems are in actuality complexes of computers, and the effectiveness of such systems depends on how well the various computers interact. Operators in such systems must understand the functional interrelationships that exist. To facilitate the development of this understanding, training of staff elements should include control over the aggregation of team members. That is, it is inappropriate, in systems as complex as the tactical data systems, to expect smoothly functioning teams to emerge when individuals proficient in their own jobs are simply brought together for exercising. Embedded training at level three is designed to develop teams proficient in using the tactical equipment, by systematically controlling the emergence of the desired team interactions.

Training objectives at the fourth level consist of system training/exercising. Training at this level is designed to fine tune the system to its fullest capability. The basic principle employed in developing system training/exercises is to train the system as a whole in an adequately simulated environment and to provide immediate knowledge of results to those participating.

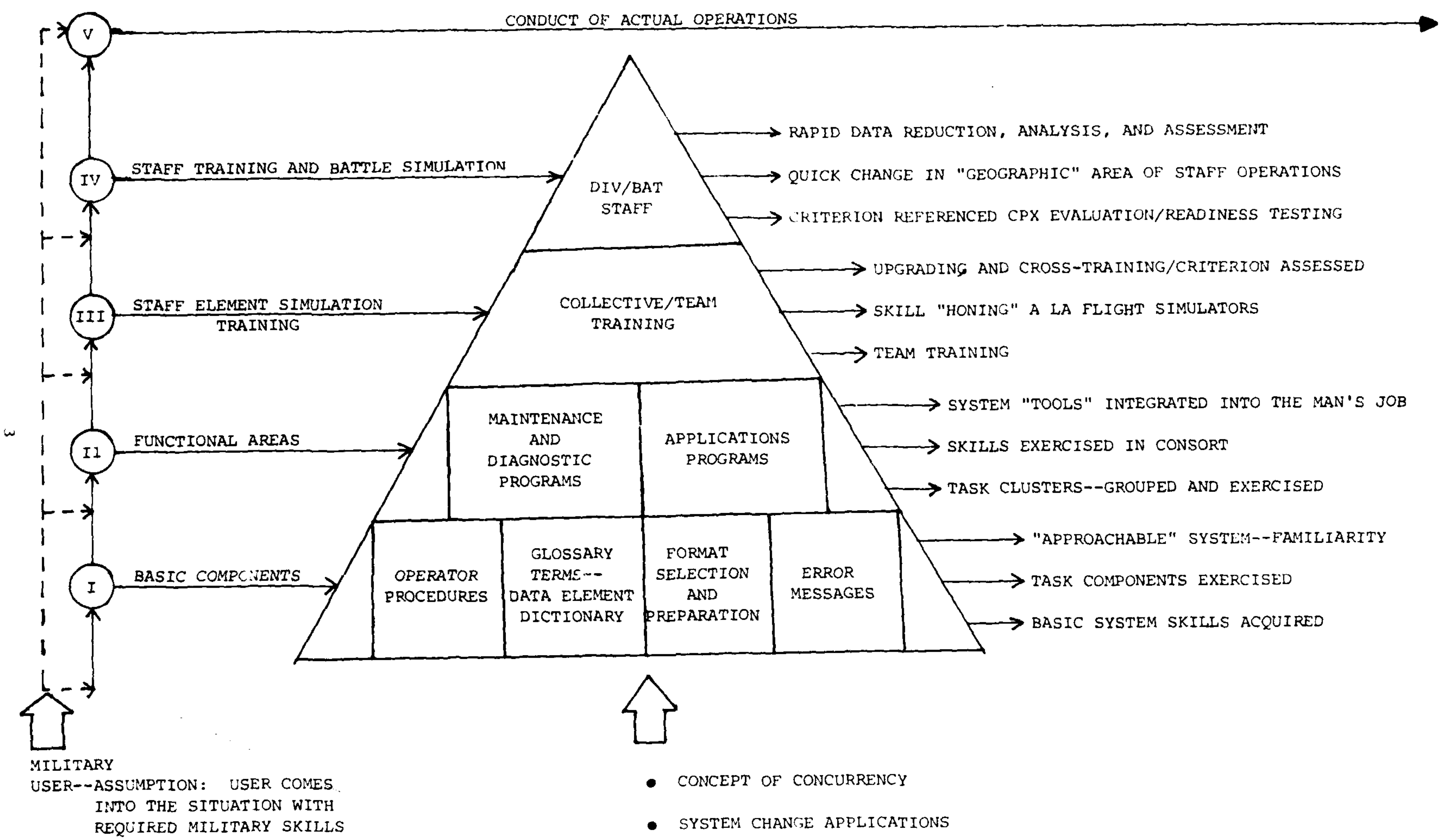

Figure 1. Four levels of training objectives in the embedded training concept.

In summary, the ET concept addresses training of the tactical data system user as a whole, wherein the system is used to teach all requisite skills--from the simplest individual skills to team skill to system skills. The feasibility of using tactical computers to support this training has been examined by ARI. The systematic development of data validating the ET concept is presented below.

VALIDATION OF THE EMBEDDED TRAINING CONCEPT

Initial research on ET, begun in late 1971, was broad in scope. The original ET concept suggested a potential, select, secondary role for computerized tactical data systems, that of directly supporting the system user by using the system itself in a stand-alone mode to teach the user to use the system. However, a number of Army organizations identified an additional function that tactical data systems might perform. This tertiary function was to support training of nontechnical, MOS-related skills and to provide general education development (GED) upgrading. The initial test of the ET concept was concerned with the potential tertiary role, i.e., it was not a test of the secondary role per se, but was propaedeutic to future research in ET.

The field study (MASSTER 122) designed to determine the usefulness of tactical computers in the tertiary role--MOS-related skills and GED upgrading--used the Army's Developmental Tactical Operations System (DEVTOS). DEVTOS was a mobile automatic data processing system that was intended to assist commanders in the conduct of tactical operations by collecting, processing, and summarizing information required for command decisions. In order to conduct the field test, a software computer-assisted instruction (CAI) authoring system which could be installed on the DEVTOS equipment had to be obtained. The cost of bottom-up production of such a software system was sufficient to eliminate this course of action from consideration. ARI chose an alternate course that began with an examination of extant CAI authoring languages. The results of the study of CAI authoring languages (Hoyt, Butler, & Bennik, 1974) led to the selection of the Programming Language for Interactive Teaching (PLANIT), a language that had a demonstrated machine-transportable characteristic. PLANIT was successfully installed on the DEVTOS system, and a concurrent effort to develop CAI packages to teach MOS and GED skills was initiated and completed.

Briefly, the design of the MASSTER 122 study may be summarized as follows: (a) All personnel were given a pretest; (b) based on the pretest scores, three groups were formed--one group received the CAI, a second group studied manuals on the same content, and a third group (a control) learned how to operate an ARI-developed source data automation device; (c) all groups were given an equated posttest. The results showed that CAI was more efficient than the traditional study method of training. Furthermore, student debriefings revealed that the NCOs in the CAI group were extremely enthusiastic about this method of instruction.

The results of this field test demonstrated the feasibility of using tactical data systems in a stand-alone mode in support of softskills unit training requirements. However, ARI's primary interest was whether tactical

computers could be used to train tactical computer operators (the secondary role). The project examining this possibility was conducted using TACFIRE (Tactical Fire Direction System) as the target tactical computer system. TACFIRE is a complex, computerized system derived from and based upon manual field artillery procedures and practices. Computer help in the artillery environment has significantly enhanced capability, but it has also brought problems. Computerization requires a high degree of specificity: precise inputs and filling in of required fields and subfields, with no margin for error.

Structuring inputs to and outputs from the TACFIRE computer, in view of the aforementioned degree of specificity, has been accomplished through the use of message formats. More than 100 message formats are used in the TACFIRE system. Figure 2 is an example of a TACFIRE message format.

```
     ;P: ;SB: / / /  /   ;C:   ;SG:  ,   ;DT:  ,  /  /  ;ID:    ;A: ;
AFU;BAMOUP;FU: / /C/1 /4Ø ;AMOR: ;AMOE: ;AMOH:X;PLAN:       ;STDODD:H/O;
PROJA:HEA1/H/ 33.Ø/6Ø6 ,HEC1/F/ 33.Ø/6Ø6 ,SMA1/S/ 33.Ø/133 ;
PROJB:SMB1/M/ 33.Ø/228 ,SMC1/E/ 33.Ø/6   ,SMD1/K/ 33.Ø/12  ;
PLOT:M67 /H/6Ø6 ,M67 /Ø/1Ø44,M67 /F/14Ø1:DTG:  /  /  ;
FZES:PDA /282 ,PDC /6Ø  ,TIA /132 ,TIB /678 ,TIJ /258 ,VTC /36Ø ;BKUP: ;
MYIELD:    /       / ,    /       / ,    /       / ,    /       /
```

Figure 2. Example of a TACFIRE message format.

Message formats to the TACFIRE system are input via an alphanumeric keyboard with an associated CRT display. The principal inputting device is shown in Figure 3.

The concept of installing ET packages on TACFIRE equipment met with some resistance, which perhaps originated in thoughts of necessary modification to TACFIRE to enable the system to operate in an instructional mode. However, the ET concept was built on the premise that the instructional system should operate in a stand-alone mode with no degradation of the operational tactical system or any additional requirements for equipment or personnel. Thus, the instructional material was to reside in the existing system hardware, which would permit the tactical operational software to be loaded directly back into the system in minutes.

The objective of the study of tactical computers in the secondary role was use of the TACFIRE system to demonstrate (a) use of CAI to train tactical computer operators, (b) use of a tactical computer to present the CAI, and (c) accomplishment of the first two objectives with no degradation of the system.

To meet these objectives, a software CAI system that could be installed on the TACFIRE equipment had to be obtained. The problem was again whether to develop a tailor-made student/author language fitted to the hardware/software constraints of the TACFIRE system or to build upon the already

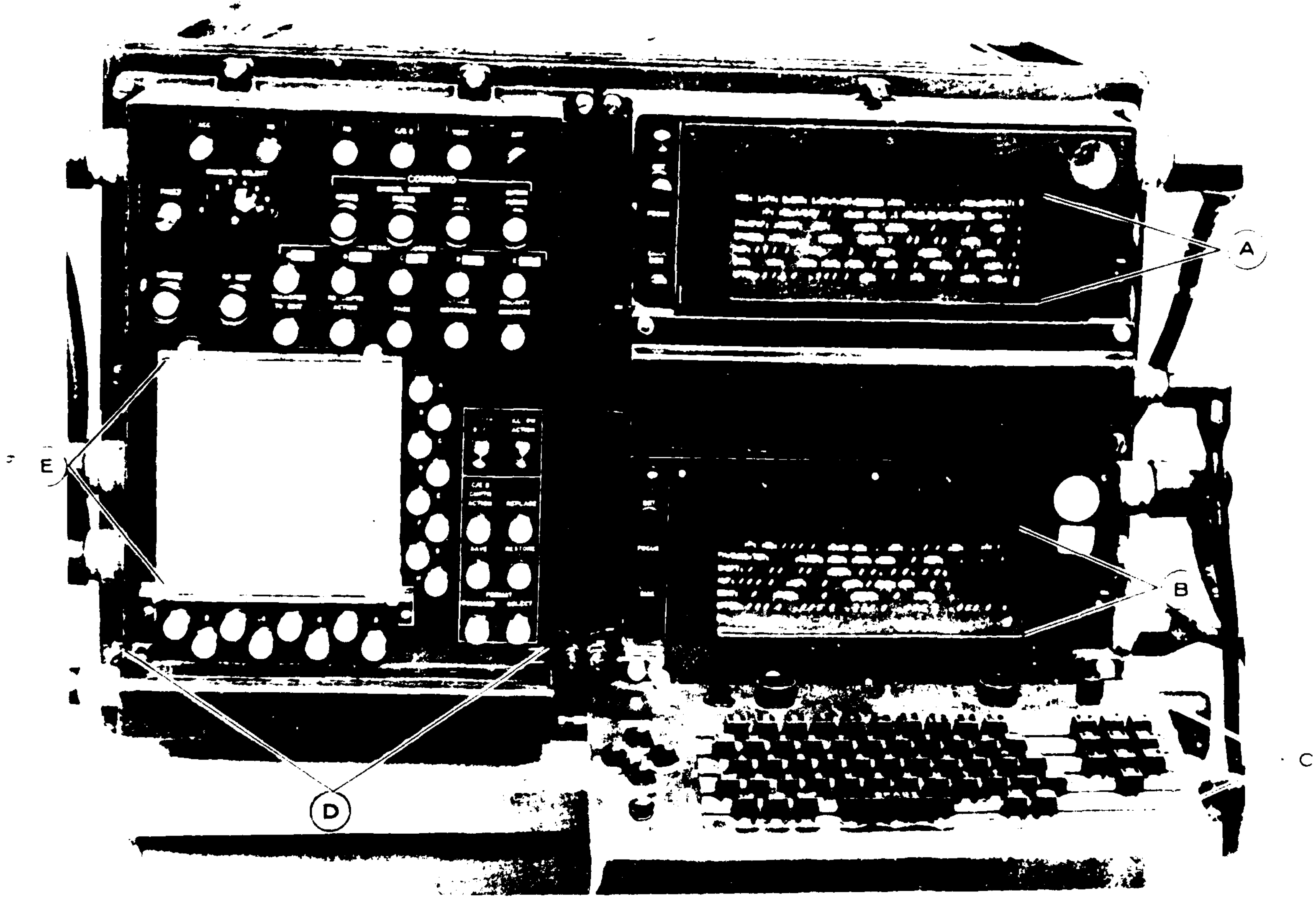

Figure 3. The principal TACFIRE inputting device—the artillery control console.

successfully operating PLANIT system and attempt to install it on TACFIRE. The latter approach had many merits: (a) it was a familiar author language system, whereas a customized system would be untested and costly and would require an extensive checkout; (b) a customized authoring system would be limited to a given TACFIRE configuration, whereas PLANIT would be transportable to the family of tactical data systems; and (c) because of PLANIT's machine-dependent characteristics, courseware could be prepared on commercial computers and, after content checkout, could easily be installed on the tactical system, whereas a customized approach would tie up the actual tactical system during courseware preparation.

A decision was made to attempt to translate the PLANIT code into the operating language used on the TACFIRE computer. The effort succeeded, and PLANIT, with all its operating features, was successfully installed on the TACFIRE system (Frye, 1975).

A test of the feasibility of ET CAI courseware was required. It was decided that the initial ET packages should be concerned with training the user who is the primary man/machine interface at each of the TACFIRE computers. This user is the operator of the principal TACFIRE inputting device, the Artillery Control Console (Figure 3).

A detailed job/task analysis was conducted on selected TACFIRE functions using the guidelines provided by the instructional systems development model (Branson, Rayner, Cox, Furman, King, & Hannum, 1975) and TRADOC Regulation 350-100-1. The course material was developed to capitalize on the previous experience of potential users (in this case, artillery) and was arranged so that the simplest TACFIRE functions were presented first. Resulting courseware was examined by subject matter experts and corrections to content were made where necessary.

In April 1976 a preliminary field test of the training effectiveness of the ET concept was conducted. Briefly, the design of the study consisted of a comparison of ET with the traditional lecture/practical exercise method of instruction. Twenty subjects, characteristic of the TACFIRE user, were divided randomly into two equal groups. Prior to receiving one of the two types of instruction, all subjects were given selected portions of an instrument designed to measure attitudes toward CAI (Knerr & Nawrocki, 1978). All instruction presented was derived from the previously mentioned job/task analysis. Subjects were released from their normal daytime assignments and were instructed in the evening hours (from 6 p.m. to approximately 10 p.m.). Subjects receiving CAI were given a copy of typed instructions on how to operate the TACFIRE terminals.

Following the 4 days allotted for instruction, all subjects took a performance-based pencil-and-paper test. The test was followed by another attitude survey (parallel to the preinstruction survey) and the CAI students were debriefed. Approximately 1 month later a second form of the final test was administered to all subjects.

The performance of the subjects on the two tests is shown in Table 1. Note that two subjects were eliminated from the analysis: One missed one full class session, and another was found to be performing his regularly assigned duties in addition to attending the evening sessions. The error rates presented in Table 1 show that the group receiving CAI made slightly

fewer errors than did the group receiving the lecture form of instruction. An analysis of variance performed on the error rates showed that the differences in performance due to different types of instruction were not significant ($\underline{F}(1/16) = 2.72$). The analysis did show, not surprisingly, that the interval of 1 month between tests produced a significant decrement in performance ($\underline{F}(1/16) = 68.19$).

Table 1

Mean Error Rates for TACFIRE Instruction

Group	$\underline{n}$	Immediate posttest	1 month posttest
CAI	9	6.2	11.0
Lecture	9	7.4	12.7

The data produced from the attitude surveys and the debriefings indicated a clear acceptance of CAI as a method of instruction for teaching TACFIRE procedures. Furthermore, the debriefings indicated that the experience with CAI and the TACFIRE computer facilitated development of the individuals' self-confidence regarding their ability to learn to operate the rather imposing TACFIRE system.

The preliminary field evaluation of the ET concept demonstrated that ET is at least as effective as traditional methods of training. This conclusion was clearly supported by data collected during the evaluation, and was strengthened by several additional considerations.

The first of these considerations is that traditional methods of instruction typically consist of lecture and practical exercise (PE). Lecture materials are developed by individual instructors who rely on their own skills and knowledge. CAI, on the other hand, is usually developed from in-depth job/task analyses. As was mentioned, however, the lectures and PE given to students in this study were based on the job/task analysis conducted for the development of the CAI materials. This provided for control over the content to which all students were exposed, but it perhaps also provided those students who received traditional instruction with a higher quality of instruction than they might usually receive in a lecture/PE situation.

A second consideration is that the class receiving the traditional instruction had only 10 students. This class was small by any standard, and perhaps size of the class enhanced the performance of the students receiving traditional instruction.

Finally, it should be noted that the students receiving traditional instruction received PE sessions on each of the 4 instructional days.

Students receiving CAI did not receive any PE, inasmuch as the interest was in determining if ET alone could carry the entire instructional load.

In summary, these considerations, in addition to the performance of the CAI students, indicate that the original question, whether tactical data systems in the field can support training of tactical data system users, can be answered in the affirmative. The study has clearly shown that an unmodified, operational TACFIRE system can effectively present instruction on TACFIRE operations to unassisted, naive TACFIRE students. While ET is at least as effective as traditional instruction for training, the relative costs of each mode of instruction must be considered to make meaningful recommendations about which system to use.

PRELIMINARY COST AND TRAINING EFFECTIVENESS ANALYSIS

The Army's concern with effective training has been heightened by increased emphasis on operational readiness in the face of tightening budgetary resources. This concern led to the development of a cost and training effectiveness analysis (CTEA) handbook for TRADOC by TRASANA. The purpose of the handbook was to provide a methodology for investigating the comparative effectiveness and costs of alternative training systems (TRADOC Systems Analysis Activity, Cost and Training Effectiveness (CTEA) Handbook, July 1976 draft). The embedded training system, an alternative to the standard instructional methods, should be subjected to a CTEA.

The stage of development of both the ET concept and the TACFIRE system precluded gathering substantial portions of the data required for a complete CTEA. However, there were sufficient data to perform a screening CTEA, as recommended in the CTEA Handbook. The type of screening CTEA considered was a training development study (TDS). The TDS, as opposed to a training-up study (TUS) or a training analysis for COEA (TAC), is appropriate in situations where an alternative training system may reduce the cost of training.

A screening TDS (STDS) is a "quick-look" CTEA that provides an estimate of potential gains to be achieved by an alternative system, ET in this case, with respect to the baseline system. The data on which the STDS is based are preliminary, in many cases not yet quantified and in some instances representing only ideas about where cost savings might occur. The data for the STDS presented here were drawn from two different applications of ET: unit training and school training.

The first application of ET is to training problems in the unit. The initial conceptualization of ET involved use of unmodified fielded tactical computers to train users in the unit. Economies in this application of ET CAI result basically from the fact that the training uses resources already committed, i.e., the costs are sunk. Traditionally, the cost of CAI is categorized into (a) hardware, (b) maintenance, (c) software, (d) instructional programming, and (e) administration. In this application of ET, hardware, maintenance, and administration may be considered essentially sunk costs. Any additional maintenance burden for the STDS may be considered negligible. The cost of software--in the case of ET,

the PLANIT authoring language--is also a sunk cost. PLANIT, developed under grants from the National Science Foundation (NSF), is available at virtually no cost. ARI's research and development (R&D) expenditures to develop and assess PLANIT's capability for ET applications represent costs associated with providing the Army with technological alternatives. With the adoption of an ARI-developed alternative by an Army agency, the R&D cost becomes, for the adopting agency, a sunk cost.

The final cost category, instructional programming, is considered by many to be very high. Some of this high cost is due to the thorough job/task analysis that must be performed in order to produce CAI of sufficient quality. However, the Army's training community, recognizing the value of the job/task analysis approach, has directed that such an approach be used in the development of all instructional material. Thus, all forms of instruction will share the cost of a detailed job/task analysis approach. Another reason for the high cost of CAI is that a particular student may see only a portion of the program available, because CAI attempts to individualize, and as many contingencies/alternatives as possible must be considered in terms of difficulty, student preferences, etc. to make courseware maximally effective over many different types of students. Although costly, treating each student as an individual has tangible payoffs such as shortened in-course times, as well as intangible payoffs such as increased student motivation.

It is apparent that ET has cost advantages over the practices of sending unit personnel to institutions for training (with attendant personnel turbulence) or of sending training teams to the field to conduct training. Further, ET has been shown to be at least as effective as traditional training. Thus, in terms of a fixed-effectiveness, variable-cost COEA model, the screening TDS of ET in the unit indicates a full-scale CTEA should be done and suggests that the outcome would favor the ET system. The ET program would seem to be a viable method of training system users in units equipped with tactical data systems.

A spin-off of the work designed to achieve an ET capability in the fielded TACFIRE units has been the projected application of the ET system in the institutional setting. TACFIRE user training is equipment intensive and thus requires a great deal of hands-on experience. The U.S. Army Field Artillery School (USAFAS) Individual-Collective Training Plan (Final Coordination Draft, 25 August 1976) estimated that to meet projected training requirements 10 TACFIRE computers would be necessary to provide needed hands-on training. This equipment would cost between $16 million and $18 million (in 1976). The ET system, as developed for use in the unit, has the capability of using one TACFIRE computer to drive up to 14 artillery control consoles. USAFAS therefore recommended that two TACFIRE computers, each with 14 training stations employing ET, be used to meet the necessary hands-on training requirement. The projected cost of implementing this recommendation, complete with ET CAI, was approximately $6 million.

Applying a fixed-effectiveness, variable-cost COEA model, a screening TDS of this application of ET again obviously justifies further study of the cost and training effectiveness of the ET system in the institutional setting.

FUTURE DIRECTIONS IN EMBEDDED TRAINING

The concept of ET represents the use of an operational computer to present training on how to use the computer that is presenting the training. A principal source of the effectiveness of such an approach is likely to be found in the cumulative benefits derived from positive transfer. These potential benefits seem very strong, considering the complexity of the TACFIRE system and devices.

Currently, the ET capability utilizes only the keyboard, one CRT, and one of the many buttons and knobs on the TACFIRE inputting device (see Figure 3). The enticement of potential gains from strong positive transfer has supplied the impetus to develop an ET capability that will not only employ all aspects of the terminal, but will appear, while in a training mode, to operate exactly as the terminal would in an actual tactical situation. This will permit an isomorphic relationship to obtain between the use of the terminal in either actual operations or training mode, while retaining the training aspects of immediate feedback, remediation when required, self-pacing, etc.

Application of the training technology previously discussed has dealt with imparting basic skills to individual students via ET (see levels one and two of Figure 1). Level three of the training pyramid represents training of the more complex group or team behaviors. Team level training has rarely been addressed in CAI research (Wagner, Hibbits, Rosenblatt, & Schulz, 1976). The team training/ET concept represents a significant departure from traditional approaches to the training of the team behaviors found at level three.

The TACFIRE system is actually a complex network of interconnected computers. Each computer participates in operator-controlled two-way exchanges of tactical data bases and other intelligence information. Furthermore, remotely located input/output devices are used to query and update data bases stored in the computers. Effective use of such a system requires operators who understand how their behavior affects the system as a whole and the individual behavior of various specific operators.

The ARI research program contains an on-going effort to develop and assess the efficacy of employing ET to teach teams of tactical computer operators. In addition, research has been directed at developing effective instructional strategies for training teams.

At the apex of the training pyramid (Figure 1), the concept of ET merges with staff-exercising and system simulation. At this level all aspects of system performance determine the effectiveness of the system, but the capability to present instructive materials is still required. This fact has been recognized in earlier attempts at system training/exercising (Powell & Streich, 1964). ARI has also been developing software to provide a potential for interfacing the operating TACFIRE software with PLANIT. This marriage would permit simulated staff exercises, based on TACFIRE software, to be interrupted by PLANIT when it becomes evident that instruction is needed. Following the instruction, the exercise could then proceed.

Development of these capabilities must occur within the following ARI-imposed constraints: (a) no change in the operational equipment, (b) no requirement for additional personnel, and (c) application in fielded systems. If, within these constraints, the staff training and simulation can be developed, a significant improvement in system effectiveness and system proficiency maintenance could be achieved.

SUMMARY

The research program outlined in this paper has been guided by the philosophy that training considerations should be part and parcel of system development. A natural outgrowth of this philosophy is to use the system to the greatest extent possible to train the users of that system. The embedded training concept is particularly applicable in the area of tactical data systems, where training and proficiency maintenance in the field present significant problems.

Research has demonstrated that the ET concept is a viable one. The results of the MASSTER 122 test clearly indicated the feasibility of using CAI on tactical data systems to train personnel in the field. The ET concept was successfully tested at levels one and two of the training pyramid in the TACFIRE evaluation study. In both cases the training was enthusiastically accepted by trainees and was at least as effective as the traditional method of training. Work addressing the problems associated with level three has produced an ET capability to present computer mediated team training. ET at level four is underway in the effort to develop software to allow PLANIT to interface the TACFIRE operational programs.

The concept of ET can be applied in a typical training setting (school), but the primary emphasis has been on applications toward meeting operational unit user requirements on a continuing and as-required basis. The concept is built on the premises that the system should operate in a stand-alone mode (no modifications to the equipment required); that the instructor be the system controller who merely flushes out the operational software and reads in the training subsystem software packages (thereby requiring no additional hardware or memory); and that returning the system to its primary tactical role merely requires reloading the operational software (accomplished in minutes). Underlying the whole concept is the notion that a highly efficient transfer-of-training paradigm has been attained in this instance--using the system itself to teach the user how to use the system!

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